Optical Media Life Prediction Methodology

R J Longman
Plasmon Data Systems

General comments

The issue of lifetime prediction for optical media is a complex subject. True lifetime prediction based on a statistically valid technique is a time consuming process and this can only be started when the drive and media are in their final production configurations. As a typical full life test takes 6 to 9 months to complete this inevitably means that product is shipped before the formal life test data is available. There are a number of ways to obtain a preliminary level of confidence and these will be discussed below.

Typical practice in the industry

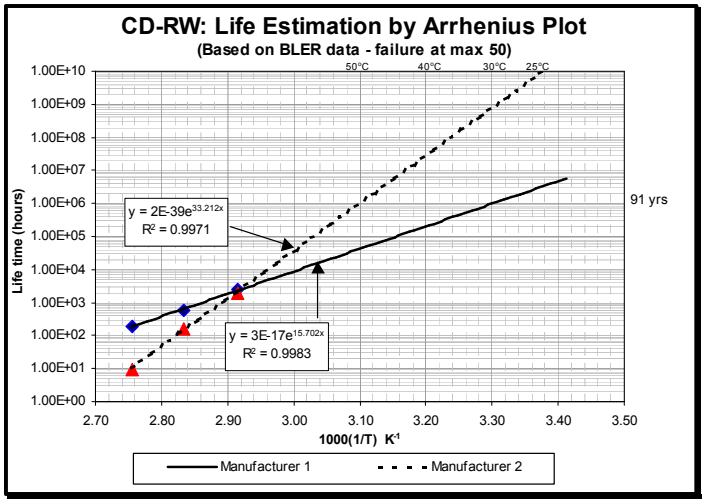
Phase Change and Magneto Optic media has historically been tested by the Arrhenius method, which involves testing at three (or more) conditions and extrapolating back to the operating environment. The Arrhenius technique is based on known scientific principles and is well established in the professional archive world as it has been used for many other products such as microfilm materials. If the fit to the Arrhenius model is good, there is a high confidence in the predictions. Plasmon has always used this methodology to confirm the lifetime of media used in professional data storage systems and we will use the same method to confirm the performance of UDO media.

In contrast to this, typical practice in the CDR/DVD-R world is to test media at one set of "harsh" conditions and claim that this can be related to a "normal usage lifetime". This assumes that the temperature extrapolation constant is well known based on multi temperature testing. In practice this is not done in the consumer products arena. The generally accepted rule is that media that passes the harsh environmental test at one set of conditions has an acceptable lifetime (often stated to be over 100 years). However, all manufacturers use this test despite the fact that they use widely different materials in their disks. In addition, there is a standard "sun test" which is used to assess the UV resistance of dye-based disks. In our evaluations almost all commercial CDR and DVD-R media made today passes this test.

Single versus multi point testing

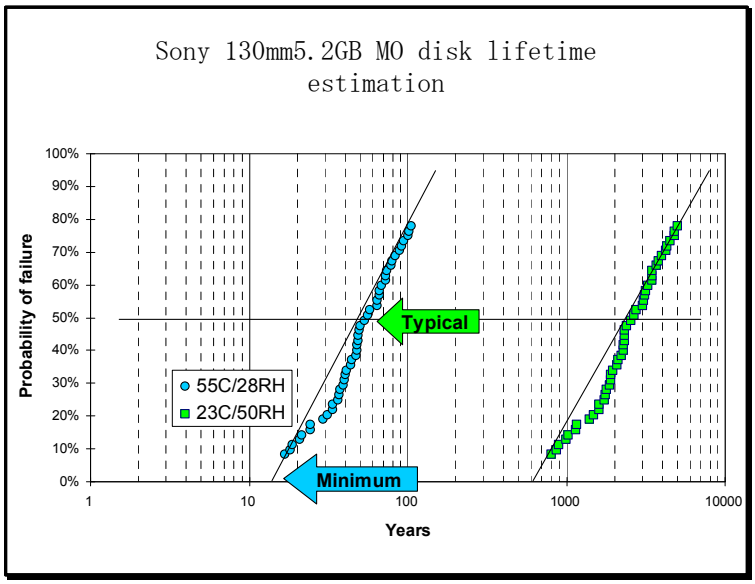
The key point to stress is that a single point test does not tell you anything about the lifetime under different environmental conditions.

As an example the graph below shows the data from two different CDRW media manufacturers. At the 70-degree point there was no difference in the lifetime but when all three conditions are tested the two media can be shown to have very different lifetimes when extrapolated to a normal storage environment because of different "rate constants".



Clearly it is essential to establish the "slope" of the Arrhenius plot or "rate constant" in order to make the extrapolation from the harsh test to normal storage conditions. Equally, this must be done using media manufactured by the final process and on drives which perform as production drives will.

In addition, enough samples must be tested to get a statistically valid result. The data below from Sony on their MO media is based on a large number of sample tests and makes it possible to apply confidence limits to the lifetime predictions.



Methods to gain early lifetime prediction prior to product shipment

In general optical media recordable film development is an evolutionary process and therefore the temperature dependency of the lifetime is known to a first order. Using this knowledge it is possible to make an initial lifetime prediction for a new system and this has been widely used in the past. Indeed, the CDR model is based on this premise, the flaw being that all manufacturers have used it despite the widely different materials used. For example, gold was the reflector layer of choice when the test conditions used today for CDR media were established. Nowadays, silver and silver alloys are universally used in CDR disks and the inherent stability of the metal is totally different from the gold used when the method was established.

Plasmon's approach has always been to combine harsh testing with Arrhenius type techniques as the product nears the end of the development cycle.

In general there are two types of failure mechanism that have to be considered in assessing media lifetimes. Firstly, the recorded mark stability has to be assessed. This is particularly important for Phase Change films, as the materials are not in thermal equilibrium. However, the mechanisms are determined by the activation energies involved and are totally predictable for a given alloy system. In this case, data from previous products can be used to predict lifetimes with a high level of confidence.

The second failure mechanism is from corrosion of the materials used in the disk construction and it is here that the harsh test finds its most useful application.

The harsh test can be applied quickly and gives an early indication of any potential problems with materials compatibility. For example, selection of bonding adhesive can be critical as they often contain chemically aggressive materials, which can cause corrosion of the very thin recording layers. An initial screening of candidate materials will quickly show up any likely problems and eliminate unsatisfactory material combinations.

Assuming that the film stability is known and that the initial screening has eliminated obvious corrosion mechanisms, a multi point test will be undertaken. Typically three elevated temperatures are used. In order to plan the test program an initial test at the most severe condition will have been undertaken. This allows the test intervals to be established, as it is essential to measure the disks at enough intervals to be able to determine the actual time that failure occurred. Typically the times to failure for the three temperatures will be of the order of a few weeks for the most severe condition up to over 6 months for the gentlest test. An initial prediction can be made after the disks tested at the two most severe conditions have been completed but full statistical confirmation can only be made after failure of the disks at all three conditions at the end of the program.

UDO media life testing

Plasmon has been developing and manufacturing Phase Change media for over 15 years and has carried out life tests on seven different recordable structures. All of these tests have confirmed lifetimes in excess of 100 years at normal storage conditions. Based on this experience and initial testing, UDO has demonstrated a media life in excess of 50 years. This stable, long life media affords data migration cycles of 10 years or longer, which dramatically reduces the overall Total Cost of Ownership for an optical archive.

A full Arrhenius life test of UDO Write Once and Rewritable media will be completed by mid-2005. Plasmon will publish the results once they are available.

For further information, please email marketing@plasmon.co.uk.

About the Author

Bob Longman graduated from Cambridge University in Mechanical Sciences in 1970. After a variety of roles in research and manufacturing development he joined PA Consulting Group in 1980 where he was responsible for the development of Plasmon's patented Moth-Eye Write Once Optical Media. He moved to Plasmon in November 1985 to develop the media manufacturing technology and has held the role of Group Technical Director of Plasmon Plc since January 1990.

During his time in Plasmon Bob Longman has been responsible for the development of many new media formats, including UDO, and for the creation of a significant consultancy business focussed on optical media development and manufacturing.